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Attentional Processes and Their Remediation in Childhood Cancer

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INTRODUCTION

Attentional processes refer to a complex system of cognitive orienting and directing skills. Deficits in these processes have grave implications for academic performance in children, because attention/concentration abilities are virtual prerequisites for the learning of any subject or skill. Unfortunately, attentional dysfunction is one of the most common neurocognitive side effects of cranial irradiation and some chemotherapies when they are used as childhood cancer treatments [1].

Attention is not a unitary concept [2], and there remains ambiguity regarding a concise definition of the components of attention and concentration. One of the more comprehensive definitions of attentional processes, particularly as they relate to cognitive rehabilitation, has been presented by Sohlberg and Mateer [3]. Those authors reviewed various theories on attention and its disorders and identified five components of attention/concentration: 1) information-processing speed, 2) sustained attention, 3) selective attention, 4) divided attention, and 5) attentional control. Information-processing speed refers to the ease and fluidity with which the individual can respond. Delays in responding and decreased reaction time, in particular, are extremely common following brain injuries of all types. Reaction time has been considered to be an important index of generalized alertness, which is also very susceptible to brain damage [4]. Sustained attention involves both the duration of time that the individual can maintain a given level of performance and the stability of the level of performance over time. This component of attention has also been labeled vigilance. Although vigilance for simple tasks is frequently preserved following brain impairment, deficits become apparent as cognitive demands increase [3]. Selective or focused attention is defined as the individual's ability to withstand distraction. This is a highly salient facet of attention that is essential for continued task performance under less-than-optimal conditions. It is extremely rare and perhaps impossible for the environment to be distraction-free. Divided attention involves the ability to simultaneously carry out more than one activity during identified periods of time. Deficits in the ability to alternate attention fluidly and effectively from one task to another would also have far-reaching implications, even for basic human activities. Finally, attentional control is conceptualized as an executive function that involves the individual's conscious ability to direct and supervise his/her own attentional resources. Susceptibility to internal distractions, such as worrying, ruminations, and impulsivity, are important considerations for effective attentional control.

The taxonomy of attention presented by Sohlberg and Mateer [3] is primarily descriptive. It is highly unlikely that the five components are independent factors, and empirical studies in the developmental literature suggest that the components may have a hierarchical structure. The ability to disengage and orient toward a target develops rapidly during the first 6 months of life [5,6]. Obtaining adequate control over the ability to sustain and shift attentional processes appears to develop by the age of 4 years [7], and performance beyond this age has been related to the development of efficient search-and-detect strategies [7,8]. Divided attentional processes develop somewhat later, and, by the age of 10–13 years, the child's abilities approximate the level of efficiency found in adult college students [9]. The conceptualization of attentional control as an executive function suggests that this ability would mature at or soon after puberty, because frontal brain development typically is not complete until this time [10]. This is speculative, however, because empirical studies on attentional self-direction have not been conducted. In general, research does appear to support the position that attentional resource capacity is present by the ages 7–10 years, and that performance is influenced strongly by efficient resource-allocation strategies rather than age per se [11–13].

Sohlberg and Mateer [14] have developed a system of cognitive retraining that addresses all of the components of attention described above. These procedures involve hierarchically graded tasks that are designed to build and reinforce skills within all five attentional components. These procedures have been referred to collectively as Attention Process Training (APT). APT has been demonstrated to improve attentional skills in adults with brain injuries, and these improvements remained stable

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over an 8-month follow-up period [15]. The usefulness of this approach with children and adolescents has been largely untested.

Long-term survival of many children with cancer has become a reality over the past several decades. Some of the treatments for these cancers, or the disease itself, can result in significant impairment in attention/concentration abilities and visual-spatial processing. These cognitive deficits negatively affect academic achievement, particularly arithmetic performance [16]. Considerable work has been accomplished in order to establish the above facts; however, there have been no programmatic efforts designed to remediate neuropsychological and academic dysfunction in these children, adolescents, and young adults. Clinical researchers in the area of brain trauma have developed a treatment program for attentional disturbances: APT. The current research project involved the development of a modified version of the APT program that emphasizes a skills-acquisition approach. The program has been designed specifically for childhood cancer survivors who received treatments that are likely to affect the central nervous system (CNS) or who suffered a CNS cancer. APT may be used appropriately with children as young as 7 years of age. The training materials, however, are clearly directed toward adult patients, and the APT stimuli are not necessarily intrinsically interesting. For this reason, we have added activities to the rehabilitation program that have an attention component but that also are designed to stimulate the interest of children and adolescents. Moreover, our experience in pilot testing the Cognitive Remediation Program (CRP) suggested that massed practice, by itself, tended to result in relatively weak treatment benefits in some subjects. The APT approach emphasizes massed practice, and we have revised this approach so that the acquisition of attentional skills and learning strategies are emphasized. We now teach the child or adolescent specific strategies that are designed to improve their performance on cognitive and school-related activities.

MATERIALS AND METHODS

Cognitive Remediation Program (CRP)

Over the course of developing the current version of the CRP, we worked with a large number of subjects in pilot studies. Practice on hierarchically graded activities designed to strengthen attentional, perceptual, and nonverbal cognitive processes was implemented. In addition, each child had an individual therapist who observed the patient's approach to the task. Ineffective strategies were identified, and new approaches were taught. For example, we found that many of the children needed to learn basic strategies, such as how to psychologically prepare themselves for success, systemically and completely scan stimulus material, periodically check their own performance, refrain from engaging in self-distracting behaviors, set personal goals, and attempt new problem-solving strategies. These are all areas that receive individualized therapeutic attention in our current program. In addition, each child received cognitive-behavioral therapy to strengthen the ability to ignore and withstand distraction. A series of activities that were designed to promote arithmetic concept development, particularly fractions and other visual-spatial aspects of mathematics, were also administered. This was included because of the common finding of an arithmetic learning disability in children who received irradiation and other CNS treatments [1]. These activities required auditory, visual, and tactile processing in order to maximize effective encoding. To increase the likelihood of generalization, children bring their school homework into therapy, and the active use of new, more effective strategies is closely monitored and encouraged.

RESULTS

A patient has completed this revised CRP, and background and treatment data are presented in Tables I and II. Test results from two previous neuropsychological evaluations on this child documented a decline in attentional processes, most likely secondary to the delayed effect of cranial irradiation. The pre- and post treatment comparisons reflect dramatic improvements in attentional skills and arithmetic competence. Whereas the subject was impaired moderately to markedly prior to cognitive remediation, after treatment, he was generally within normal limits and gained 1.5 to 2.0 grade levels in arithmetic skills over 6 months of therapy. Although we cannot be certain that these gains are due primarily to the treatment efforts, to our knowledge, there were no other significant changes in the patient's school instruction or general life during the 6-month period of therapy. We have enrolled several additional patients into this study and continue to be encouraged by our preliminary results.

DISCUSSION AND CONCLUSIONS

For the past several years, we have been developing and pilot testing this CRP, which was designed to improve attention and concentration skills in children, adolescents, and young adults who have been treated for cancer. This program also includes activities that will stimulate nonverbal cognitive processes. Many cancer treatments, although they are effective, can result in significant cognitive dysfunction, which has a negative impact on the individual's quality of life. Our efforts at developing this treatment program have been programmatic and evolutionary. Pilot studies have been conducted, and this program now is ready for a large-scale evaluation of its effectiveness. The remediation program

TABLE I. Background and Attentional Remediation Effectiveness for Pilot Subject Using Revised Rehabilitation Program*

Date	Verbal IQ	Digit span (WISC-III)	Arithmetic (WISC-III)	Sentence memory (WRAML)	Arithmetic (WRAT-3)
Baseline					
10/92	83	10	5	8	65
05/94	90	5	6	7	76
07/94	—	8	6	7	72
Treatment					
03/95	—	7	7	9	95
Applied problems grade equivalent (W-J)		3.0[a]		4.9[b]	
Calculation grade equivalent (W-J)		3.3[a]		4.7[b]	

*The patient (subject 9) was a male, 10 years of age, with a diagnosis of brain tumor who had received cranial irradiation (2,000 cGy). WISC, Wechler Intelligence Scale for children; WRAT, Wide-Range Achievement Test; W-J, Woodcock-Johnson.
[a]Pretreatment.
[b]Posttreatment.

TABLE II. Continuing Performance Test (CPT) Results*

Measure	Value (%)	T-Score	Percentile	Guideline
CPT pretreatment				
No. hits	289 (89.2)	—[a]	98.50	Markedly atypical
No. omissions	35 (10.8)	—[a]	98.50	Markedly atypical
No. commissions	30 (83.3)	58.67	83.28	Within average range
Hit RT	427.29	37.32	10.27	A little slow
Hit RT SE	16.15	74.28	99.00	Markedly atypical
Variability of SEs	47.48	68.03	96.43	Markedly atypical
Attentiveness (d′)	0.27	67.17	95.69	Markedly atypical
Risk taking (B)	0.74	100.00	99.00	Markedly atypical
CPT posttreatment				
No. hits	323 (99.7)	—[a]	20.01	Within average range
No. omissions	1 (00.3)	—[a]	20.01	Within average range
No. commissions	24 (66.7)	50.38	51.50	Within average range
Hit RT	441.50	34.99	8.06	Atypically slow
Hit RT SE	7.52	50.90	57.55	Within average range
Variability of SEs	13.44	50.57	56.23	Within average range
Attentiveness (d′)	2.65	42.42	22.46	Within average range
Risk taking (B)	0.02	40.22	16.42	Within average range

*The patient (subject 9) was a male, 10 years of age, with a diagnosis of brain tumor who had received cranial irradiation (2,000 cGy). RT, reaction time; SE, standard error.
[a]For hits and omissions, nature of data dictates use of percentiles only.

is a manageable length (i.e., 6 months), school absences due to therapy attendance are minimized (i.e., a single, 2-hour session per week), and the program is very transportable to other institutions with minimal staff training (i.e., materials are readily available from national distributors, and a detailed manual has been developed). We suspect that this treatment program is promoting therapeutic gains by teaching patients to martial and manage their own cognitive resources more effectively. In addition, the process of cognitive exercises may be improving the brain's ability to process information rapidly. We also believe that the CRP has a strong psychotherapeutic component that bolsters self-worth and self-image. Although the CRP will require continued revision in order to further amplify its effectiveness, we believe that it has progressed to a point of sufficient clinical promise.

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